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Agriculture Development Fund

FINAL REPORT

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WHEAT STRAW QUALITY CHANGES DURING STORAGE

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Final Report

Wheat Straw Quality Changes During Storage

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1. Summary

Straw usage and its total availability for use by industry, and even for livestock, requires the preservation of straw over at least a 12-month period. Attempts to provide reserve inventory for drought years would mean even longer storage may be necessary. This had led for the need for research to examine the effect on quality of different bale storage methods and the losses of straw that would result.

In this project, both round and square bales from a field of CPS wheat were stacked using three different methods. These included an uncovered stack, a tarped stack, and a stack built on a bed of loose straw and covered with loose straw. Straw samples were collected from each stack for 14 months. Straw quality for all samples was assessed.

In general, it can be concluded that the quality of the straw within the bales was not affected by stacking methods, but weathering losses are affected by stacking method which will affect the available quantity of good quality straw. Tarping and a straw layer under the bale stack appear to reduce loss as much as possible. Spoilage losses can be very high, up to 40% in the worst case, and could be much higher in a wet year.

2. Technical Report

2.1 Introduction

The economics of growing wheat are marginal and many people are interested in extracting more value from the crop by utilizing the straw for industrial purposes. Examples of these uses are strawboard, pulping, and ethanol plants. To accurately analyze the economic viability of a plant and to ensure straw supply is sustainable, it is vital that reliable data on straw availability exists. Maps describing straw availability on the prairies have previously been developed by PFRA. Because of the limited amount of data available, some assumptions of straw to grain ratio, straw recovery and the effect of variety had to be made. This project, along with two others, was carried out to provide current data on straw availability throughout Saskatchewan as a function of grain yield and to relate this data to the actual amount of straw realized after combining, baling, and storage.

In this project, round and square straw bales were stored, and the quality and quantity of straw monitored over a course of 14 months. The other two projects investigated straw available throughout the province, and the portion of the straw recovered during harvesting and baling.

2.2 Objectives

The objectives of this project were to:

1. Obtain and store round and square bales in three different types of stacks.

2. Monitor the quality and quantity of straw over a fourteen-month time period.

2.3 General Description

All bales for this project were obtained from one field of AC Crystal CPS wheat near Humboldt, Saskatchewan. A John Deere Model 9600 combine was used to combine all of the wheat. A New Holland Model 271 baler was used to make all square bales. A Gehl Model RB1860 baler was used to make all round bales. The square bales were all 14 in. high x 18 in. wide (356 x 457 mm) and the round bales were all 5 ft (1.52 m) wide and approximately 6 ft (1.83 m) diameter with a hard core. All square bales were weighed on either a Massload platform scale or the PAMI vehicle scale, and all round

bales were weighed using the truck scale at Humboldt Flour Mills. The square bales were stacked by hand and the round bales were stacked using a front-end loader. To collect straw samples, a probe was built by PAMI for this project, and measured 2 in (51 mm) in diameter and 38 in (965 mm) long (**Figure 1**).

Figure 1. Bale Stack Sampling.

2.4 Scope of Test

2.4.1 Field Tests

All combining for this project was done in late August 2000. Baling was completed not more than three days after combining, and stacking was carried out soon after that. The straw was not rained on before initial stacking. All stacks were initially located at PAMI in Humboldt. However, the stacks were being altered regularly by local children, so they were moved to a location north of Muenster, Saskatchewan in late October 2000 before any damage had resulted.

Three stacks were made with each type of bale. Each square bale stack had 200 bales, and each round bale stack had 10 bales. Stack configuration is shown in **Figures 2** and **3**.

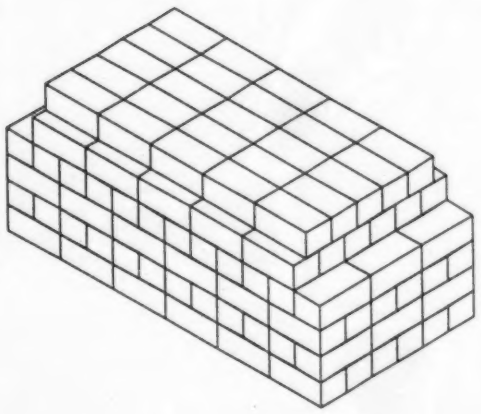

Figure 2. Square Bale Stack Configuration.

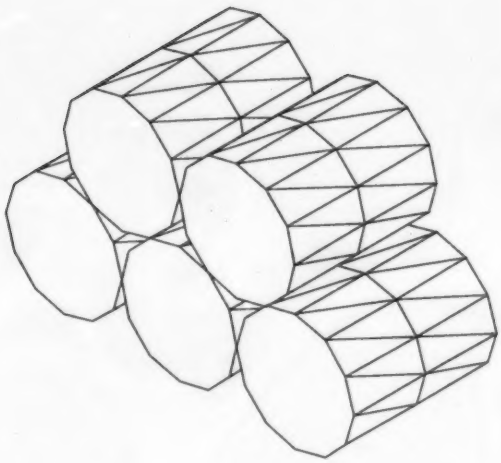

Figure 3. Round Bale Stack Configuration.

Both square and round bale stacks were made using three methods. One of each stack was made by simply constructing the stack on the ground with no subsequent covering. One of each stack was stacked on the ground and covered with a tarp. The third stack of each was constructed on the top of a bed of loose straw about 8 in (203 mm) thick. When the stack was complete, loose straw was forked onto the top of the stack by hand (**Figure 4**).

Figure 4. Bale Stacks.

After all stacks were constructed, samples were taken from all stacks at monthly intervals. Four samples were collected from each stack, and the samples consolidated. The sampling locations were chosen so that samples were not collected from the same location more than once, and the consolidated sample was a reasonable representation of all straw in the stack.

At the conclusion of the tests, all stacks were taken apart and the entire stack weighed. The bales were then assessed, and straw that was weathered or rotten was discarded. The remaining good straw was again weighed. Samples of good, weathered, and rotten straw were collected for quality analysis.

2.4.2 Lab Tests

All samples collected were submitted to the Department of Agriculture and Bioresource Engineering at the University of Saskatchewan. In the lab, four types of tests were done. These included moisture content, colour, a sieve analysis, and shear strength tests. The following are descriptions of each of these tests.

Moisture content tests were done by collecting a 10 g (0.35 oz) sample of straw, determining the mass, and placing the sample in a drying oven at 103°C for 24 hours. The final mass of the sample was then determined and the difference in mass used to calculate wet basis moisture content.

To determine colour, a sample of straw was ground to a powder in a precision grinder. This sample was then placed in a Hunter Labscan Colorimeter.

A particle size analyzer was used which conformed to ASAE standard S424.1. It consists of a series of screens with defined hole sizes that are shaken in a specific motion. The entire straw sample was placed in this analyzer and the unit operated for six minutes. The mass of material on each screen was determined and a statistical analysis was done of the data.

After sieve analysis, the straw captured on the third sieve was collected and used for a shear strength test. The test procedure was developed specifically for this project and is described in ASAE/CSAE technical paper #SD01-119. A 10 g (0.35 oz) sample of straw was placed in a box and a lid was placed on top. A razor blade was then pressed through the straw and the force and displacement measured as the straw was cut. After the test, a string was tightened around the straw and the diameter measured. This was used to determine the straw area. The maximum force and this area was used to calculate the shear stress for each sample.

When the stacks were disassembled, a sample of good, weathered, and rotten straw was collected from each stack. The above four tests were done on all of these samples.

2.5 Results and Discussion

2.5.1 Lab Tests

Moisture Content: Moisture contents of samples taken from all stacks are shown in **Figure 5**.

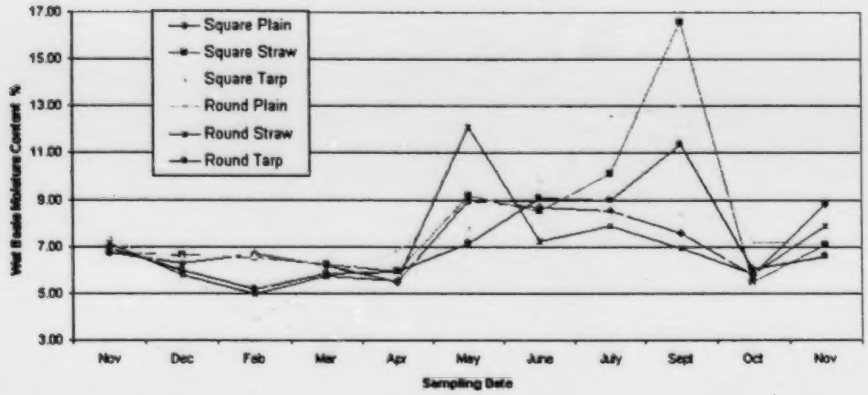

Figure 5. Bale Moisture Contents Over Time.

Based on the above data, it appears that all bales, regardless of stack type, had the same internal moisture content. This is not surprising, as the samples were taken from within the bale. Local moisture contents at the bale surface may have revealed differences between stacking methods. Moisture contents did not change from the initial level until after May, which is expected, since it is unlikely that straw can take on moisture until after winter.

At test completion, most good straw was dryer than the weathered or rotten straw (**Figure 6**). This was expected, as it is excessive moisture content that causes, straw to rot.

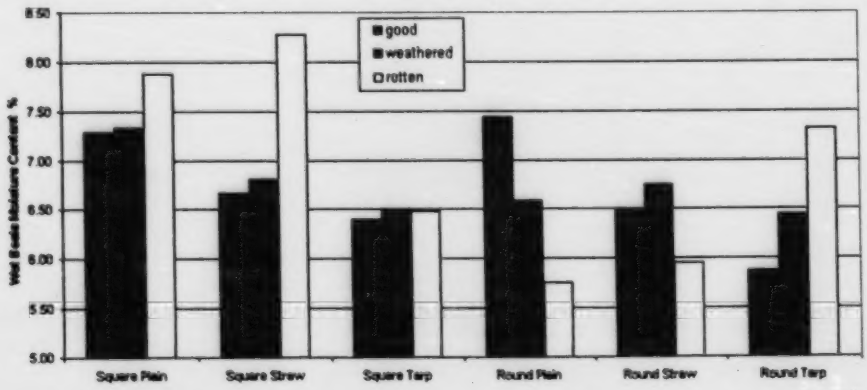

Figure 6. Straw Moisture Contents at Test Completion.

The exception to this was the Round Plain and Round Straw stacks, where the driest straw was the rotten sample. This was possibly due to a sampling anomaly. Because of the low rainfall during 2001, it was noted during stack disassembly that some of the rotten straw was not wet as is normal. It should also be noted that these straw samples were primarily collected to assess shear strength and other qualities, so collection was not totally geared toward moisture determination.

Colour: Results from the straw colour assessments are given in **Figures 7, 8, 9,** and **10.**

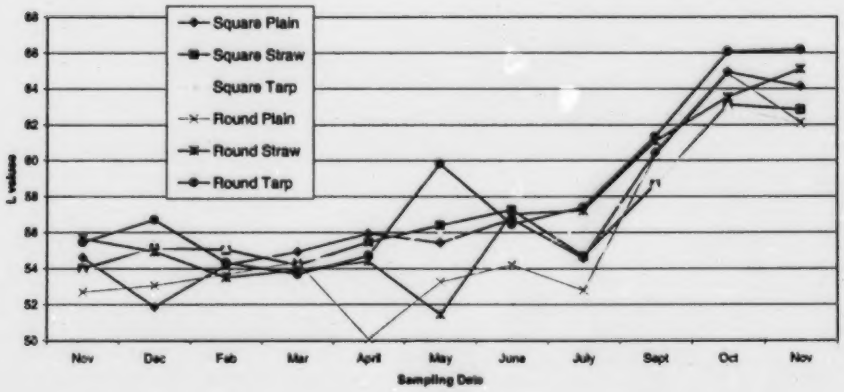

Figure 7. L Colour Values Over Time.

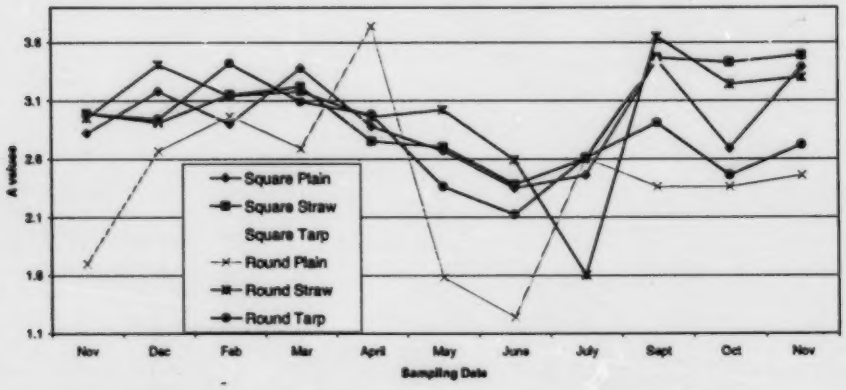

Figure 8. A Colour Values Over Time.

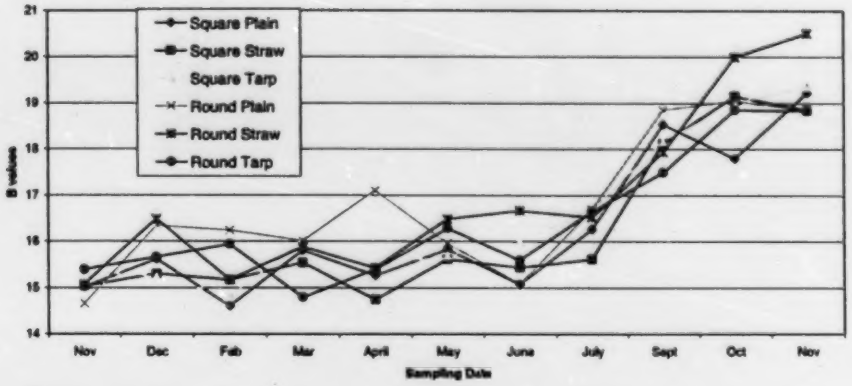

Figure 9. B Colour Values Over Time.

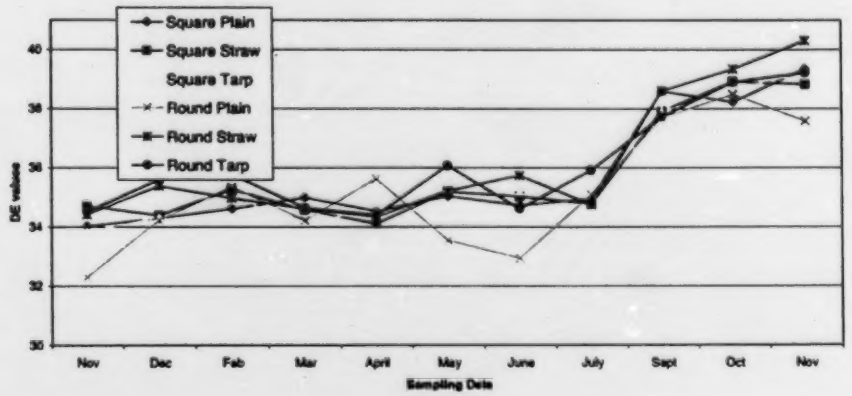

Figure 10. DE Colour Values Over Time.

The L values in **Figure 7** are an indication of the relative lightness of the straw. From this data, it appears that the straw colour changes with time, and in fact, its overall lightness increases. This information may be relevant to strawboard manufacturers or other straw based industries where aesthetics are an issue. It appears that stacking method does not affect colour over time.

The A values in **Figure 8** are an indication of the degree of redness of the straw. It appears that this straw characteristic changed slightly with time, reaching a low at early summer and then returning to near initial values at test completion. Most stacking methods showed similar results, with the Round Plain stack results being slightly more erratic and volatile.

The B and DE values shown in **Figures 9** and **10** are an indication of the degree of yellow and total colour difference respectively. Both values show similar trends as the A value in that they increased with time and were not dependant on stack type.

Results from the straw colour assessments at test completion are given in **Figures 11, 12, 13,** and **14.**

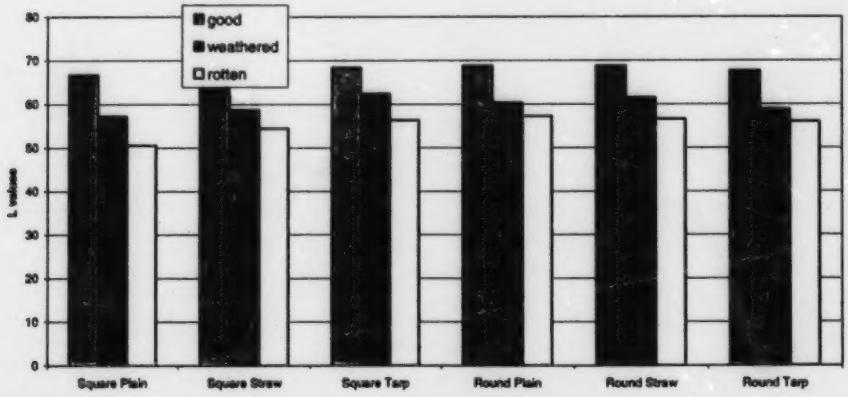

Figure 11. L Colour Values at Test Completion.

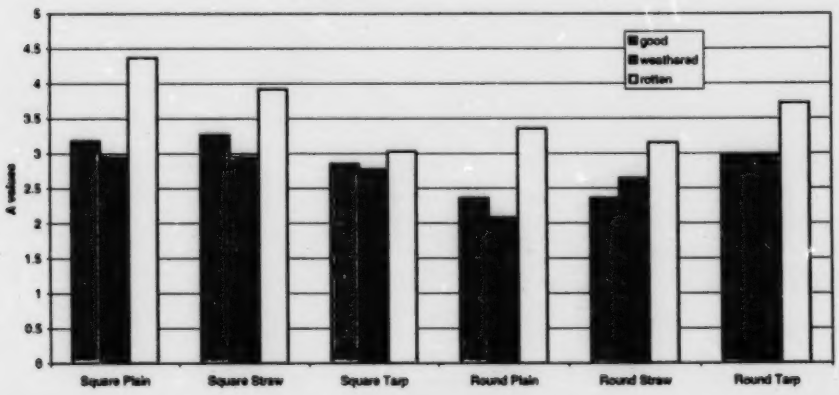

Figure 12. A Colour Values at Test Completion.

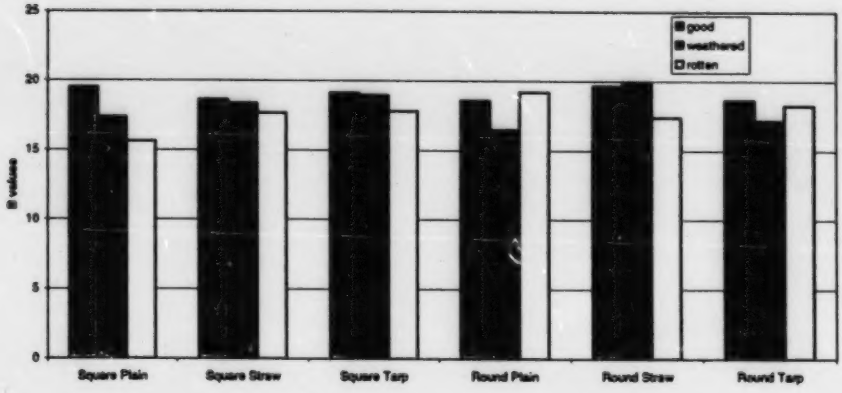

Figure 13. B Colour Values at Test Completion.

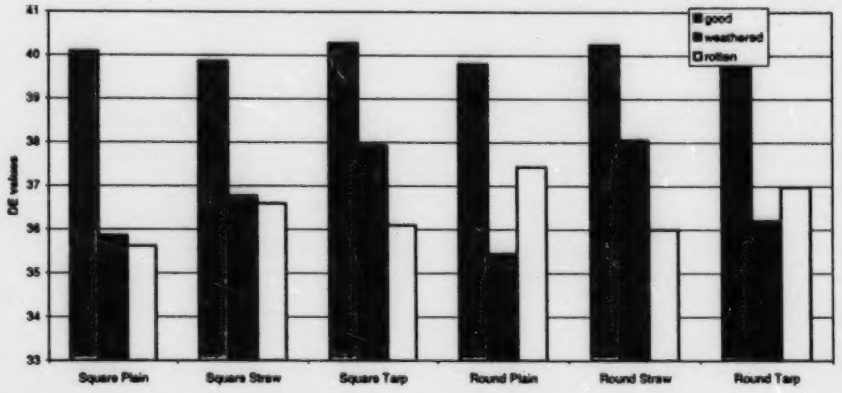

Figure 14. DE Colour Values at Test Completion.

In all cases, the L values from the good straw is higher than the other samples, which in expected, since straw gets a duller colour as it degrades. As was evident over the course of the test, the A values were slightly different for the Round Plain stack. The B values indicated no major differences between stacks. The DE values showed a marked difference in colour between the good and other straw, which is logical. The data also indicates that there are small differences between stacking methods but no major definable trends.

Particle Size Distribution: Results from all particle size distribution tests are given in **Figures 15** through **20**.

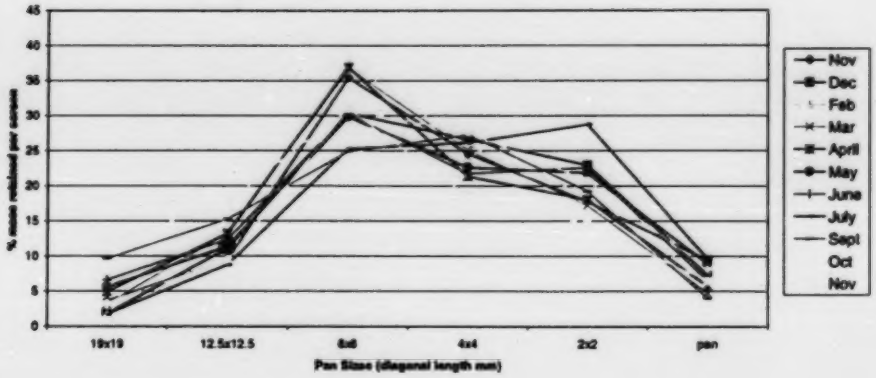

Figure 15. Square Plain Particle Size Distribution.

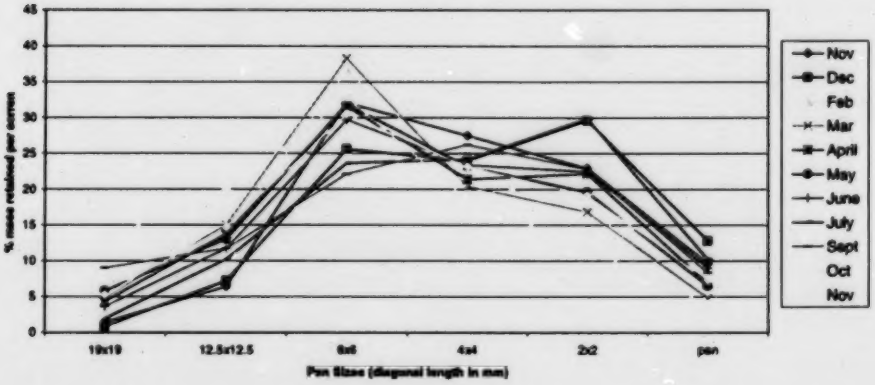

Figure 16. Square Straw Particle Size Distribution.

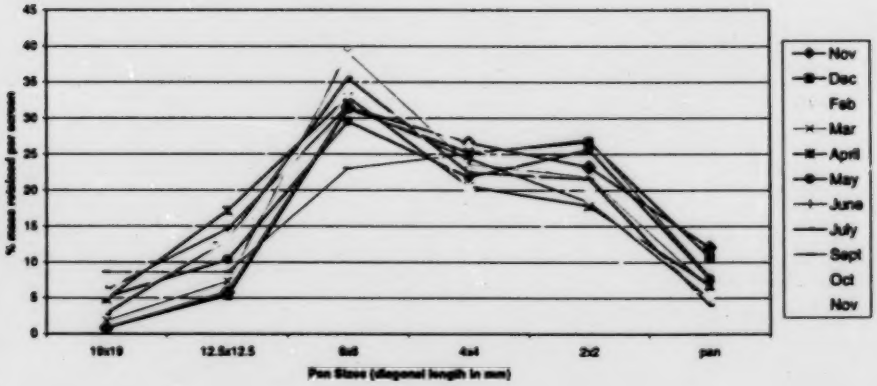

Figure 17. Square Tarp Particle Size Distribution.

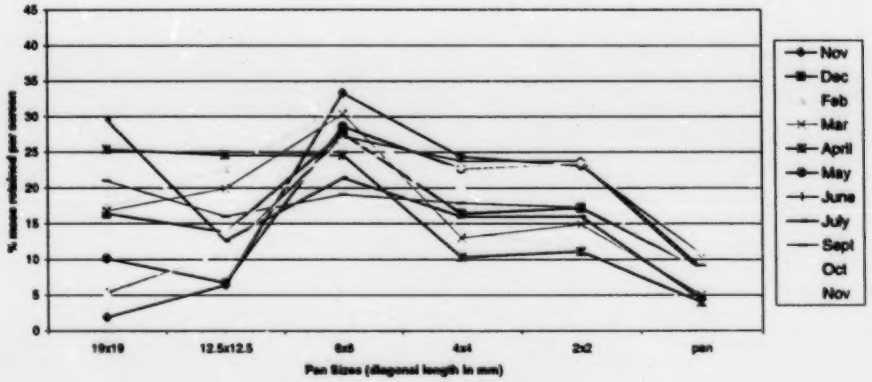

Figure 18. Round Plain Particle Size Distribution.

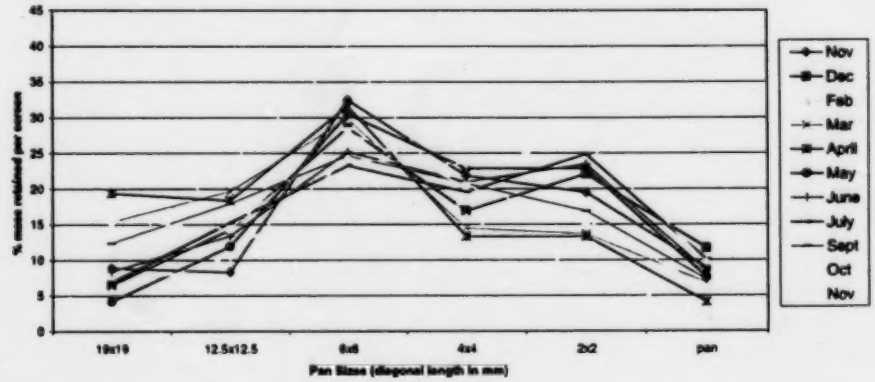

Figure 19. Round Straw Particle Size Distribution.

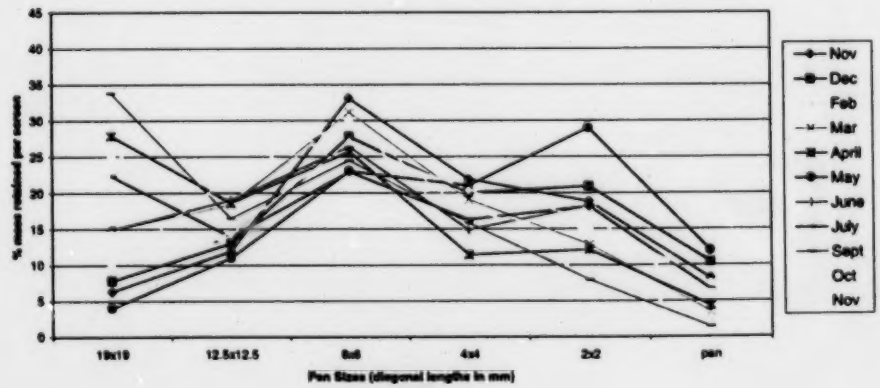

Figure 20. Round Tarp Particle Size Distribution.

All of the above results indicate that there were no major differences in particle size distribution over time or between stacks. The round bales had more variation within the long straws than the square bales. This is logical because a square baler cuts the straw with each plunger stroke and round balers do not incorporate this action in their operation. However, this indication should not be used to make any definite conclusions about straw quality for the following reasons. Firstly, the samples were obtained using a coring device that may have altered the particles sizes in the sample. Also, these tests were only meant to be an indication of straw strength, as it was thought that if the straw strength was greatly reduced, it may tend toward smaller particles. In any case, because there were no marked differences in particle size distribution, no significant conclusions can be drawn.

Results from particle size distribution tests at test completion are given in **Figures 21, 22,** and **23**.

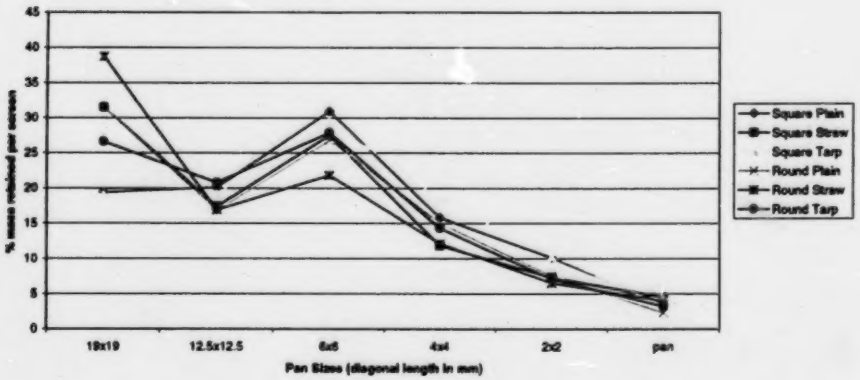

Figure 21. Good Straw Particle Size Distribution.

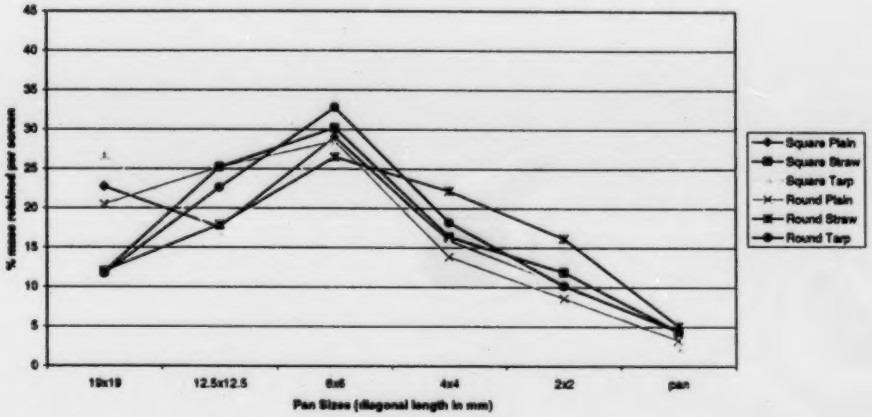

Figure 22. Weathered Straw Particle Size Distribution.

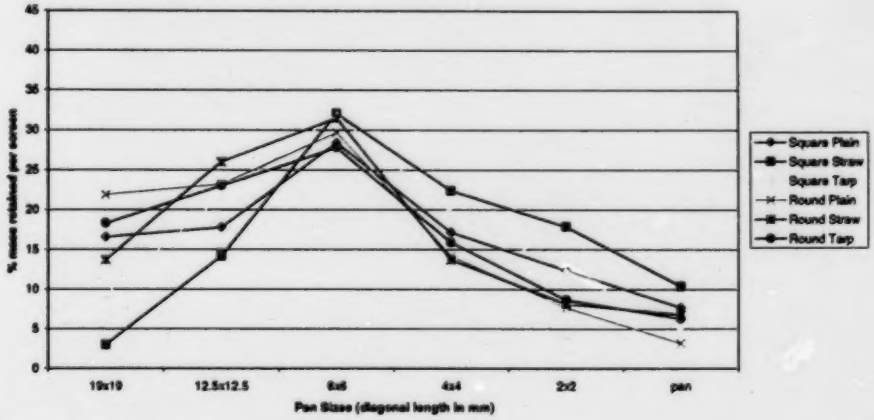

Figure 23. Rotten Straw Particle Size Distribution.

From the above data, it is apparent that the good straw had more large particles than the weathered or rotten straw. This is logical, as the weathered and rotten straw is closer to complete decomposition than the good straw. The particle sizes at the 12.5 x 12.5 mm (.49 x .49 in) screen and smaller were similar for all samples.

Shear Strength: Shear strength tests results over time are given in **Figure 24**.

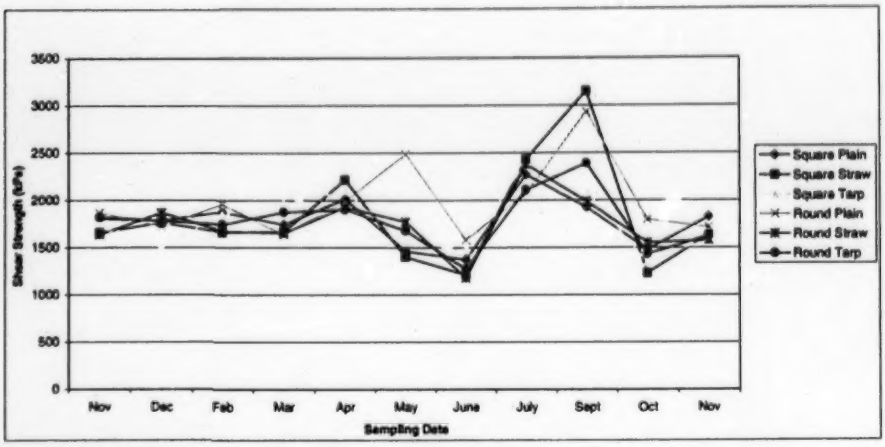

Figure 24. Straw Shear Strength Over Time.

The above results indicate that there was some variation in shear strength over the course of the year, but it returned to the initial level at test completion. The change in shear strength occurred at the same time as straw moisture content, which may indicate a relationship between the two. There was no difference in shear strength between different stacking methods.

Straw shear strength at test completion is shown in **Figure 25**.

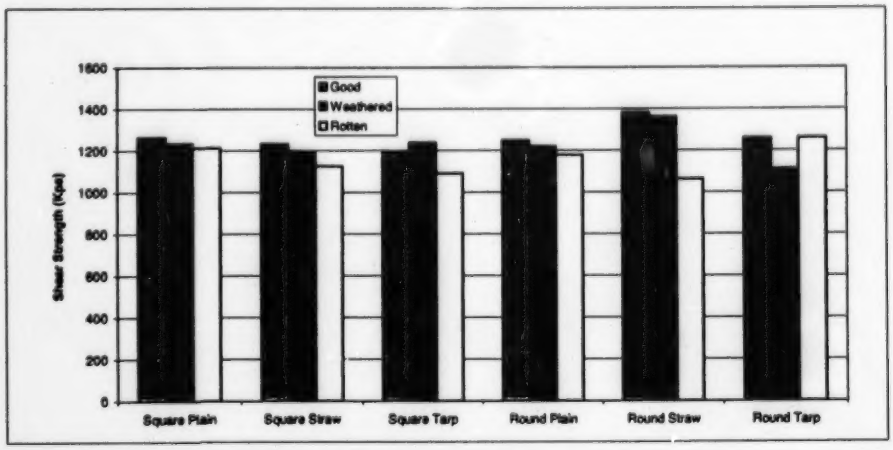

Figure 25. Straw Shear Strength at Test Completion.

Although there are small differences in shear strength between stack types, there are obvious trends that may indicate that stack type affects shear strength. In most cases, there were small differences in shear strength between good, weathered, and rotten straw, with the good straw having the highest shear strength in almost all cases. The

only result that may tend toward a difference in shear strength is that both the good and the weathered straw from the Round Straw stack appeared to have a slightly higher shear strength than others.

2.5.2 Field Tests

The Percent of Original Mass Remaining at Test Completion results are given in **Figure 26.**

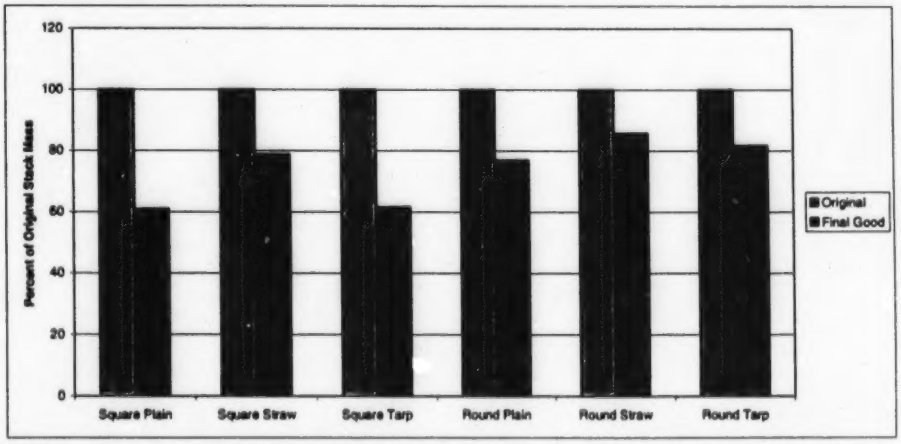

Figure 26. Percent of Original Mass Remaining at Test Completion.

In general, round bales preserved the straw quantity better than square bales. For both bale types, the plain stack had the lowest percentage of good straw and the straw covered stack had the highest. During stack disassembly, it was noted that a large portion of the straw that was discarded was from the bottom of the stack, and because the straw covered stacks had straw under the bales, there was little or no loss from the bottom of these stacks. It is interesting that with the square bales, the recovered straw from plain and tarped stacks were nearly identical. It appears that if a tarp is used, it must be maintained or there will be little or no gain from it. It was noted during stack disassembly that there were some holes or tears in the tarp, and where these occurred, rotten straw resulted adjacent to the hole. It appears that tarps can be an effective method to reduce straw quantity loss, but if they are not maintained they can also trap moisture in the stack and increase spoilage. Perhaps a combination of straw (or other material) under the stack and a well maintained tarp would result in the minimum straw quantity loss.

2.5.3 Overall Conclusions

In general, from the lab tests it can be concluded that stacking method had little or no effect on the quality of the samples collected. This is not surprising, as all samples were collected from inside the bales where any different weathering effects due to stacking methods would be minimized.

It can also be concluded that stacking methods does affect final straw quantity and that perhaps a combination of straw under the stack and a well maintained tarp system can be used to preserve straw as much as possible. Whether straw or some other means of separating the straw from the ground would be most effective is not known. In these tests, in the worst case, with no cover and no straw under the stack, almost 40% of the straw was lost due to spoilage. In the other stacks, this loss was reduced to about 20%. It should be noted that the 2001 storage year had record low rainfall and normal or higher rainfall would likely change these values and possible magnify the advantages or tarps or straw used either above or below the stack.

3. Personnel

3.1 PAMI Manpower Supplied

It is PAMI's policy to charge rates that include salary and benefits of employees as well as overhead. These charge rates do not include profits and to ensure that overhead is not charged to the project, indirect services, management time and use of PAMI equipment are provided at no cost. It has been calculated that this adjustment removes more than overhead costs from actual charge rates. It is PAMI's policy not to release individual salary information. The hours and costs recorded here are those charged to the PAMI accounting system as of March 12, 2002.

4. Equipment

No equipment was purchased for this project.

5. Project Developed Materials

No materials were developed as a part of this project. All information will be forwarded to Lawrence Townley-Smith at PFRA.

6. Project Photos

Photos for this project are contained in the body of the report.

7. Acknowledgement

Results from this project and the other two associated projects were presented at the Agriculture and Greenhouse Gas Climate Change Workshop in late 2000 and at the Agricultural and Forestry Biomass for Energy Supply Workshop in Ottawa on November 27 and 28, 2001. Both ADF and AAFC were acknowledged as funding agencies during these presentations.